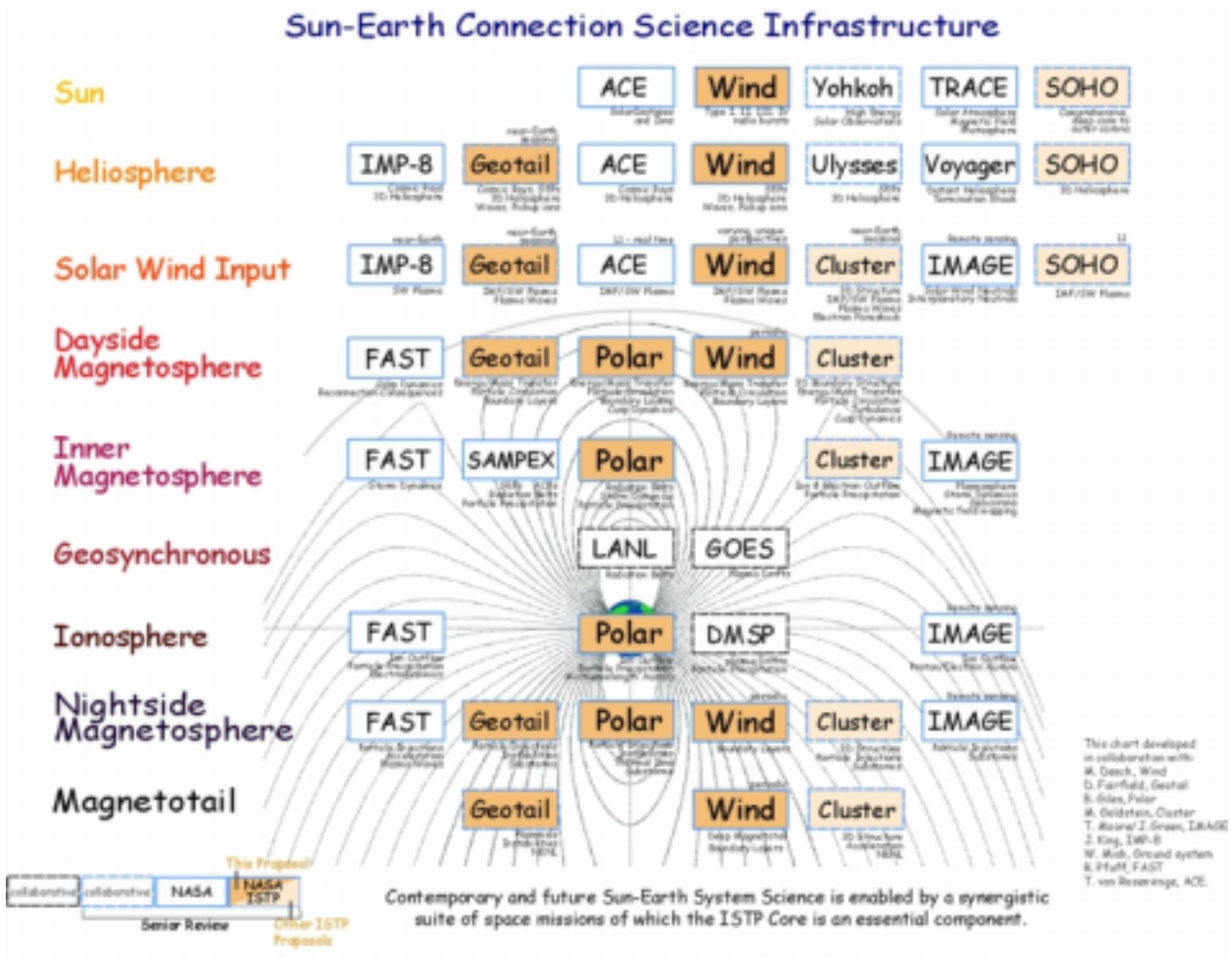
ISTP/GGS

Global Geospace Science for the International Solar-Terrestrial Physics Program

Terence Onsager - Community Representative
Mario Acuna - ISTP/GGS Project Scientist
Keith Ogilvie - Wind Project Scientist
Robert Hoffman - Polar Project Scientist
Donald Fairfield - Geotail Project Scientist
Steven Curtis - Theory, Modeling, Ground based Project Scientist

ISTP/GGS Importance of ISTP/GGS Program

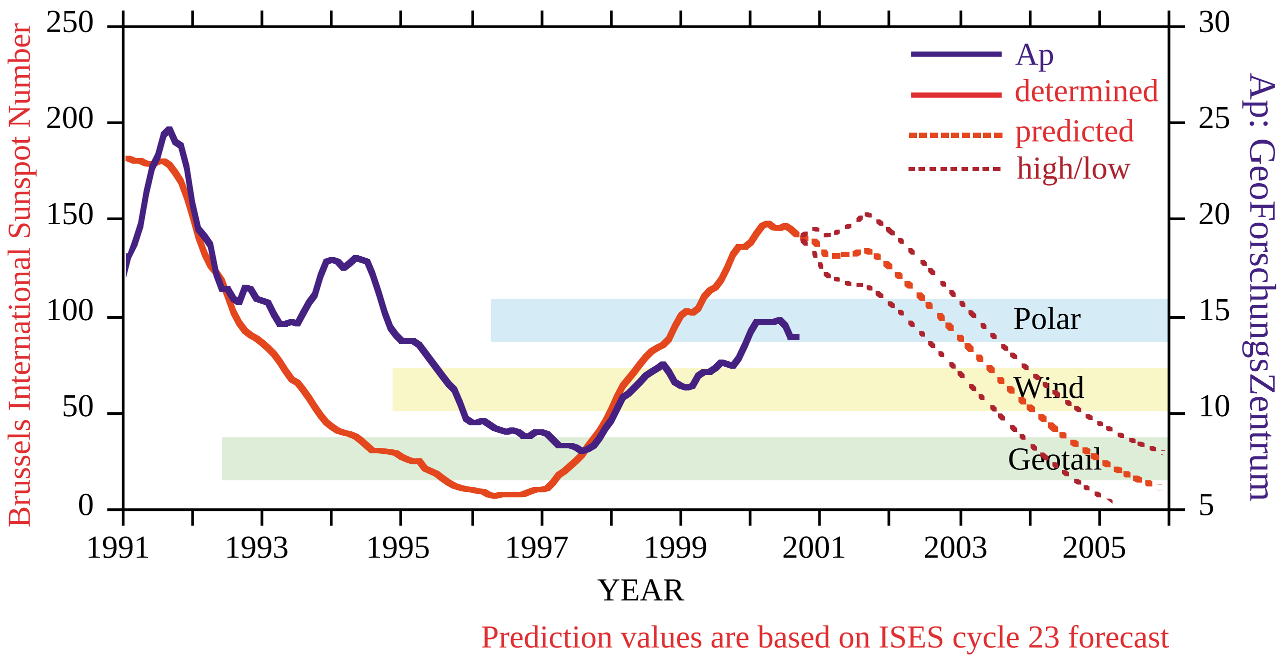


ISTP is NASA's only integrated, distributed laboratory for SEC science. It examines the global variable response of geospace to solar influences and seeks to understand the underlying dynamics on large and small spatial and temporal scales.

ISTP/GGS

Elements of the program

- Geotail
- Wind
- Polar



- Ground-based Investigations
- Theory & Modeling Investigations

ISTP/GGS

ISTP/GGS Accomplishments I

Four ISTP/GGS discoveries and three insights significantly changed SEC science:

1) The discovery that the deep magnetotail does not hold the key to magnetosphere dynamics. The "action" is much closer to Earth and there is still work to be done to determine where and how the action starts.

2) The discovery that collisionless reconnection occurs in the solar wind, at the solar wind / magnetosphere interface, and in the magnetotail, and is “the” most important energy transfer process between the solar wind and magnetosphere.

3) The discovery that the terrestrial source of plasma can mass load the outer magnetosphere system very quickly after solar impulsive events and may be a catalyst or even a driver of magnetospheric dynamics

4) The discovery that features of interplanetary structures are more complex than previously believed. For example, shock fronts in the solar wind can be so steeply inclined that they reach Earth before they are observed at L1. Therefore, assumptions based upon cartoons of the interaction of the solar wind and magnetosphere cannot always be relied upon.

ISTP/GGS

ISTP/GGS Accomplishments II

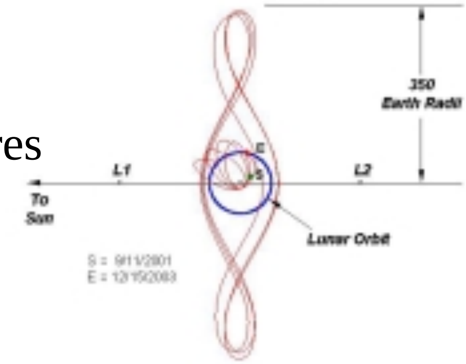
5) The realization that the response of the magnetosphere to solar wind inputs varies with the nature of the input, which in turn varies with the phase of the solar cycle. This was suspected before ISTP/GGS, but is now much clearer.

6) The determination that physics-based global models of geospace, when coordinated with single point satellite observations, can produce dynamic images of geospace on which predictions can successfully be based.

7) The utility of radio-based tracking of CME's has been firmly established. In this way CMEs have been shown to overtake and interact with one another.

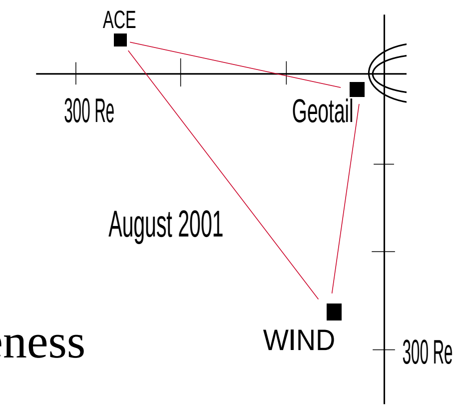
ISTP/GGS

Heliosphere Observing Campaign



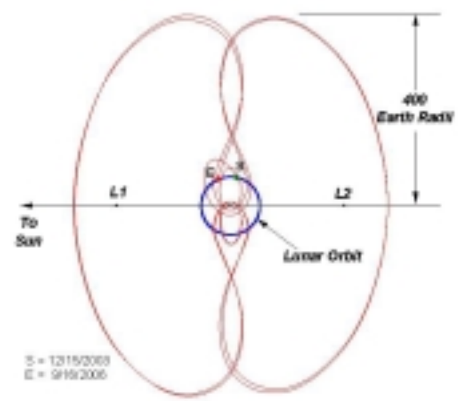
Objectives:

- Coordinated, detailed observations of mesoscale solar wind structures
- 3-D radio wave observations of CME shock fronts
- Support models of solar wind structure and evolution
- Observations of gradual and flare-accelerated SEP events



Anticipated Results:

- CME classification and the consequences of colliding CMEs
- Relationship between CME shock speed and SEP acceleration
- Large-scale morphology of solar wind structures
- Structures of solar wind MHD turbulence
- Relationship between structures and their sources and geoeffectiveness



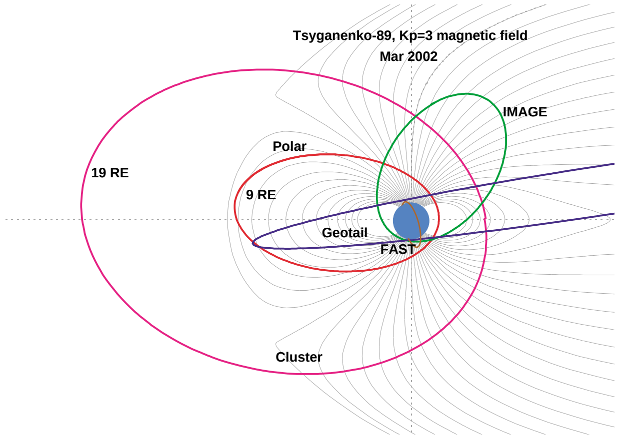
Significance:

- First large spatial scale observations of interplanetary structures
- Wind observations act as a Stereo pathfinder
- Deals directly with the OSS theme "Nature of Solar Interactions with the Earth's Atmosphere and Space Environment"

ISTP/GGS Dayside Magnetosphere Campaign

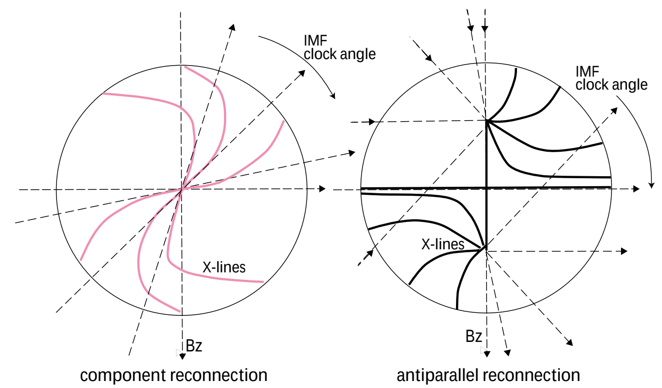
Objectives:

- Multi-satellite observations of dayside reconnection events under a variety of solar wind conditions
- Full coverage of particle phase space for the various plasma populations involved



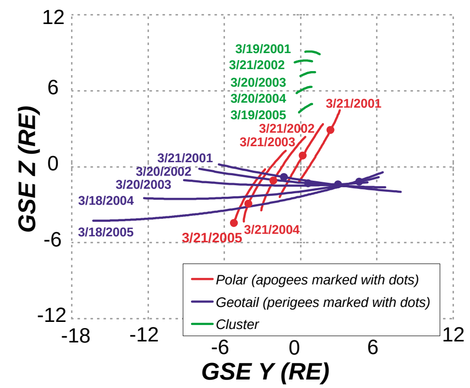
Anticipated Results:

- Identification of the important reconnection processes/sites
- Quantitative understanding of the energy/mass transfer
- Definitive source-to-destination flow paths for solar and ionosphere source particles



Significance:

- Only the simplest of connections result from steady IMF and solar wind boundary conditions, GGS enables the next step.
- Ideal configuration of properly instrumented spacecraft not likely to be repeated in the near term
- Because reconnection is a fundamental process occurring throughout the solar system, these results will address the OSS theme "Comparative Space Environments"

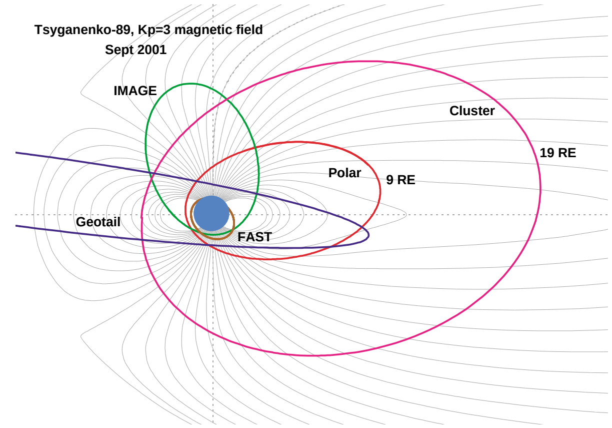


ISTP/GGS

Nightside Magnetosphere Campaign

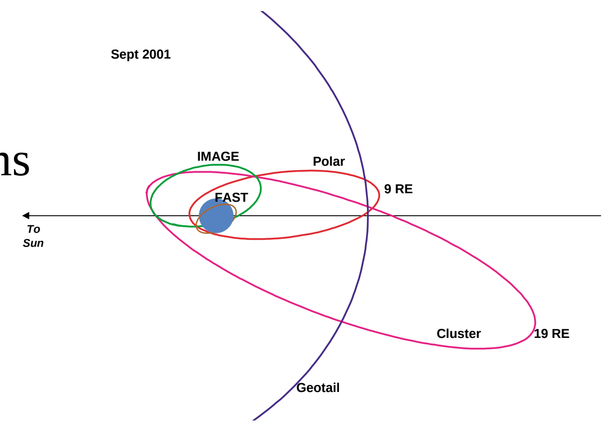
Objectives:

- Near-simultaneous sampling of tail reconnection and near-Earth instability regions
- Full field and particles measurements in regions associated with ring current and radiation belt dynamics
- Definitive observations of ionosphere contribution to plasma sheet



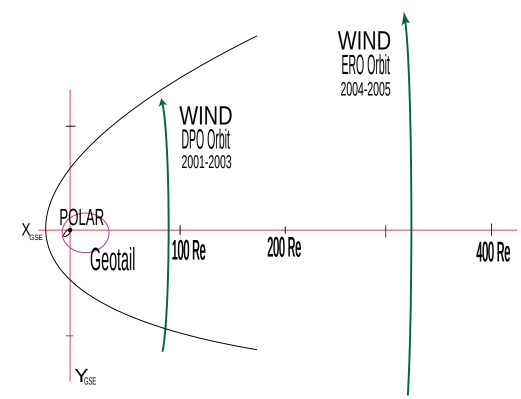
Anticipated Results:

- The long awaited understanding of substorm dynamics
- Relative importance of radiation belt acceleration mechanisms
- The role of ionospheric plasma in magnetosphere dynamics
- Relative importance of storm recovery mechanisms
- Deep magnetotail structure and dynamics



Significance:

- The "nail in the coffin" on the substorm dynamics problem is widely desired
- Ideal configuration of properly instrumented spacecraft not likely to be repeated in the near term
- Deals directly with the OSS quest "How do the Earth and Planets Respond to the Sun"



ISTP/GGS

Extended Mission Objectives

1. We will extend the systems-science approach, describing the dynamic processes associated with the decline of the solar cycle.

2. We will understand the dynamic processes associated with the equatorial region of 2-30 R_E .

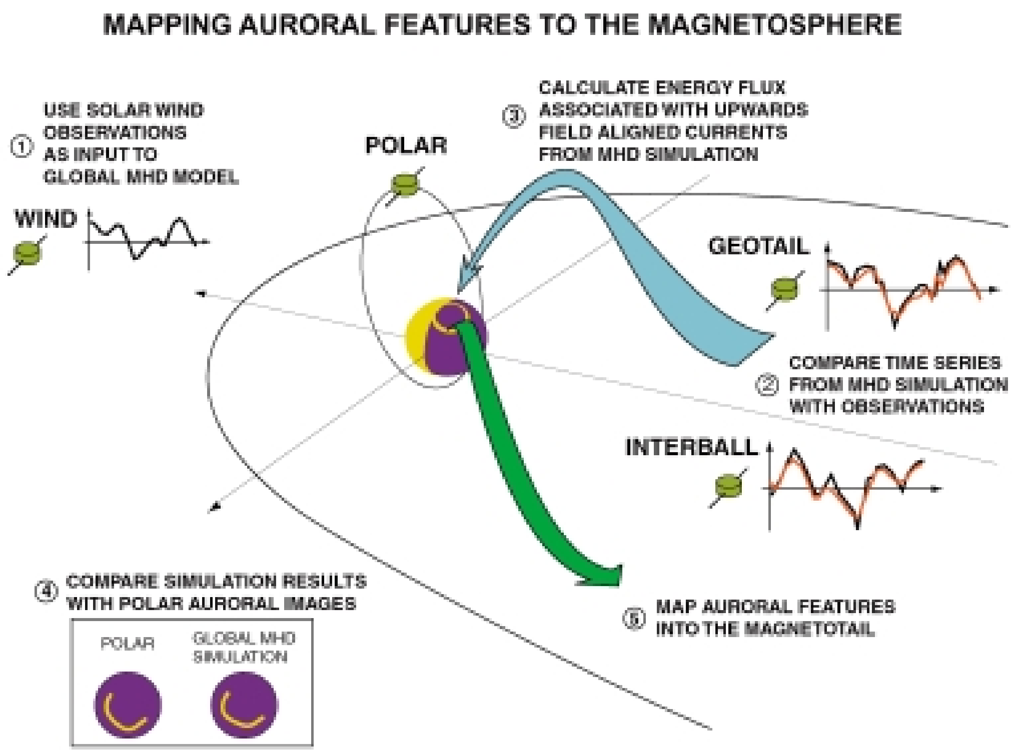
3. We will investigate the global consequences of magnetic reconnection.

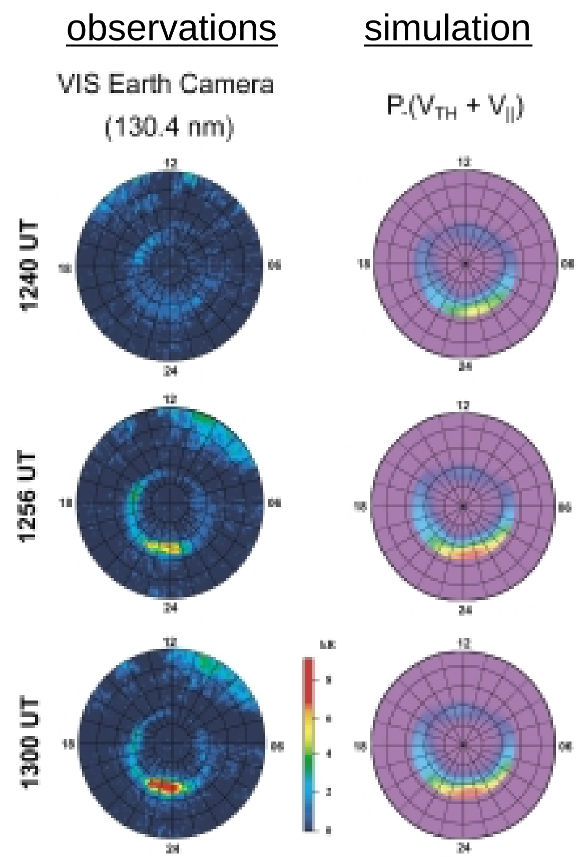
4. We will quantify the 3-D structure and evolution of large-scale interplanetary configurations and their interaction with the magnetosphere.

ISTP/GGS

Program Element 1

Extend the systems-science approach, describing the dynamic processes associated with the decline of the solar cycle.

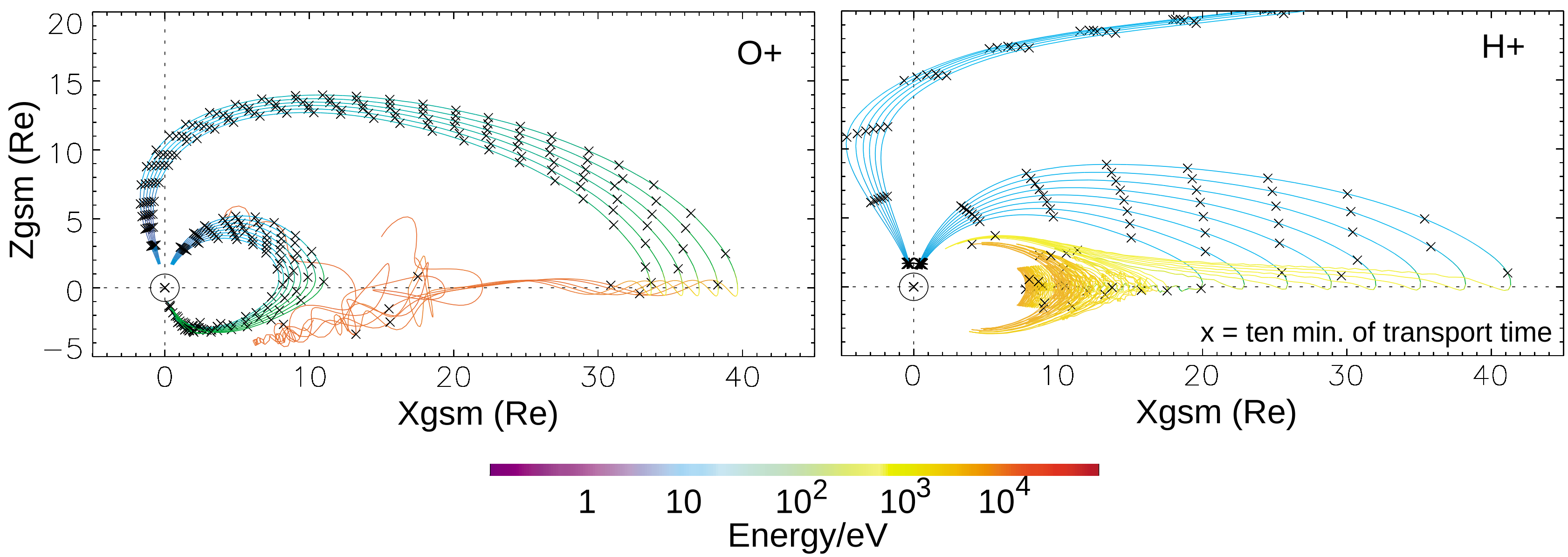




Utilize the declining phase of the solar cycle to test the global simulation models against the effects of high speed streams with their resultant relativistic electron events.

Understand the Dynamic Processes Associated with the Equatorial Region of 2-30 R_E:

A. Quantify the relative influences that solar and terrestrial source plasmas have on dynamic equatorial processes

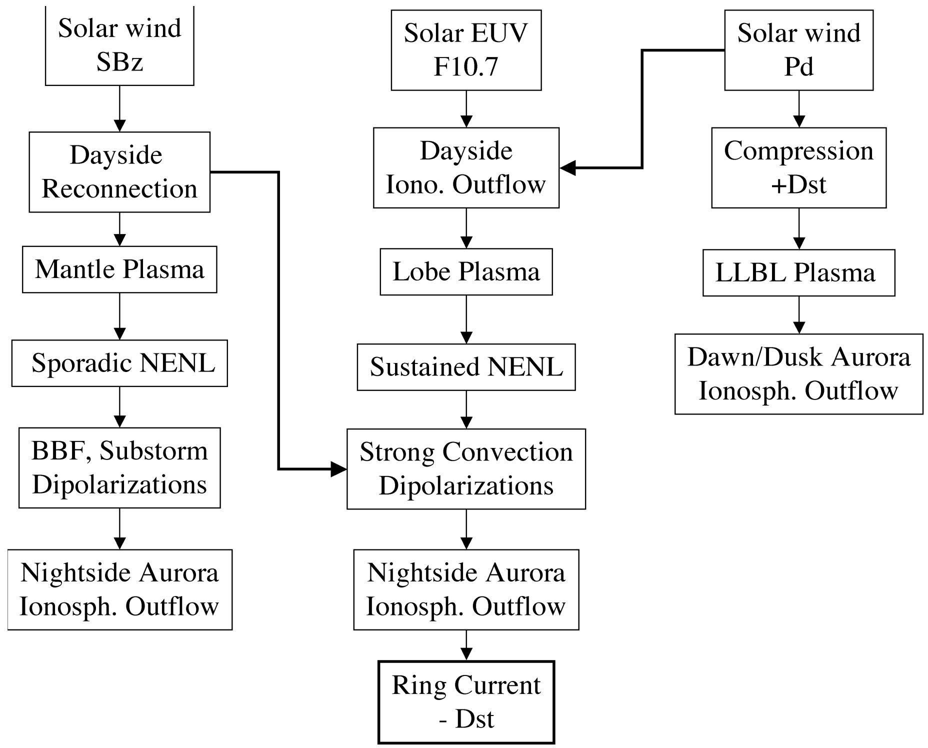


To what extent does the flow of solar and ionosphere plasma directly influence magnetosphere dynamics, act as a catalyst, or simply exist as a moderating influence?

ISTP/GGS Program Element 2b

Understand the Dynamic Processes Associated with the Equatorial Region of 2-30 R_E:

B. Determine Equatorial Storm Plasma Injection and Loss as a Function of Solar Input



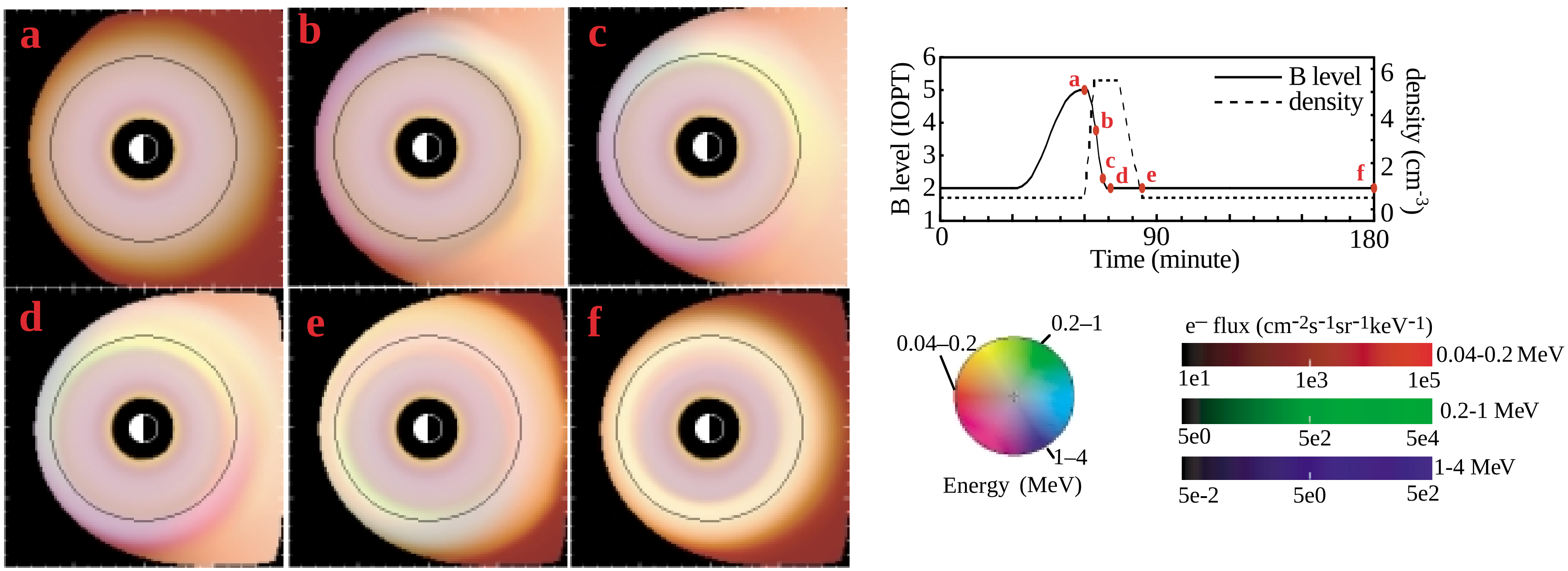
Is storm recovery controlled by the decay of cross-tail and magnetopause currents, by the convection of ring current ions out of the magnetosphere, by H^+ and O^+ charge-exchange differences or by enhanced wave-particle interactions?

ISTP/GGS

Program Element 2c

Understand the Dynamic Processes Associated with the Equatorial Region of 2-30 R_E:

C. Understand Radiation Belt Time Variations and Their Direct Connection with Solar Variability



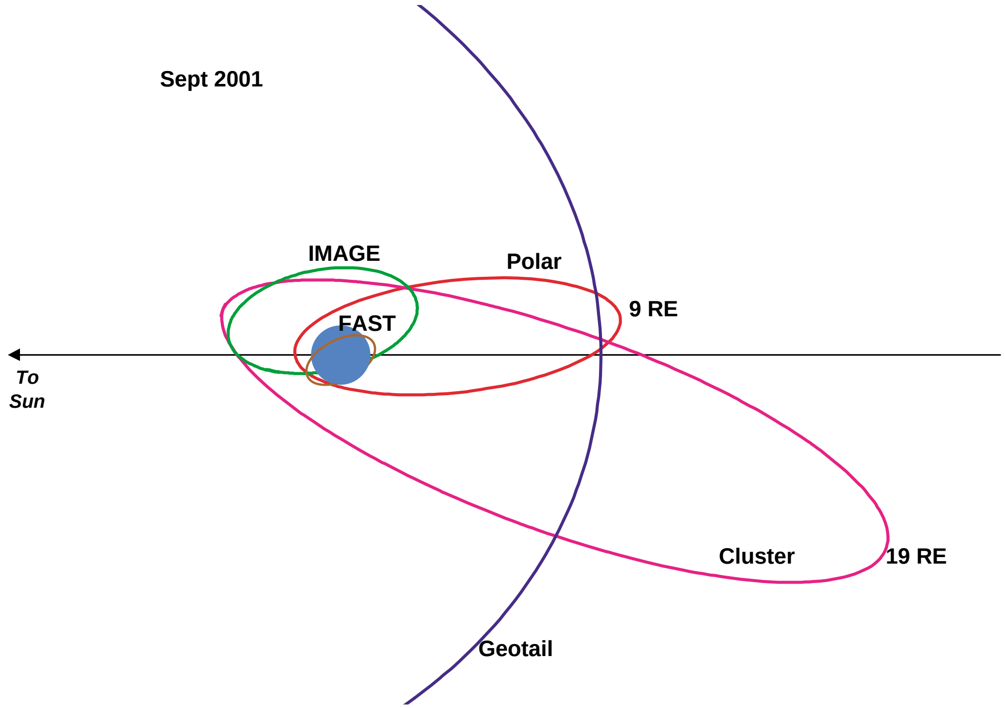
What is the relative importance and what governs the intensity of the processes responsible for accelerating electrons to relativistic energies? Why are recurrent high-speed solar wind stream more effective in producing intense radiation belts?

ISTP/GGS

Program Element 3a

Global Consequences of Magnetic Reconnection:

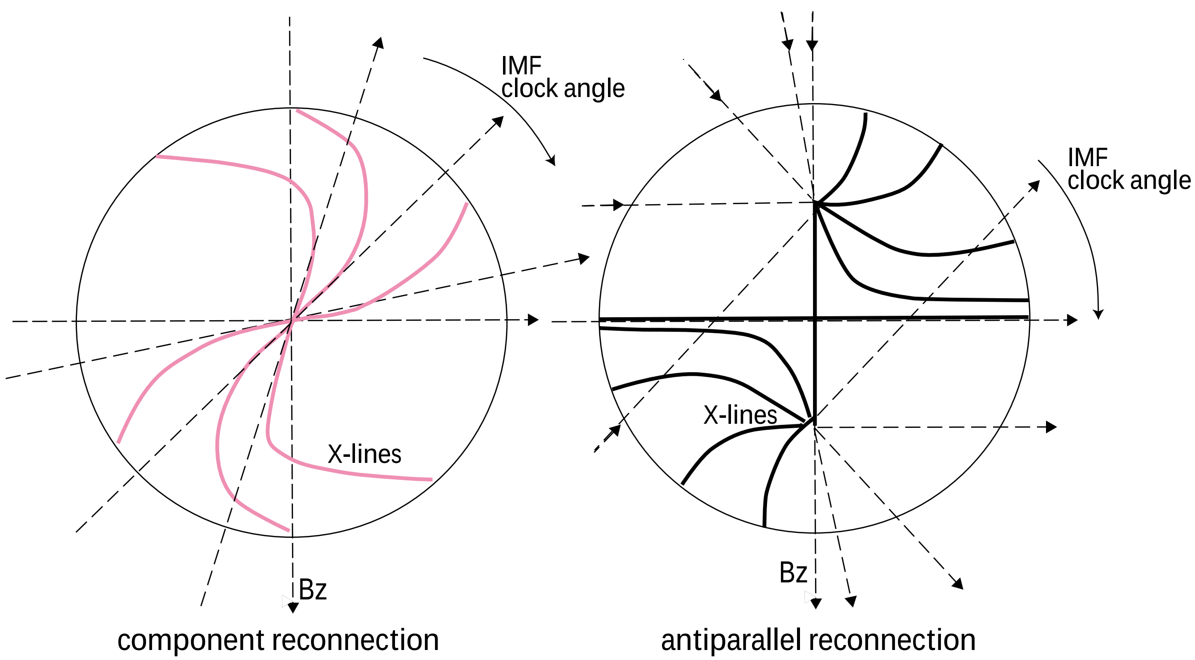
A. Understand Substorm Onset Processes: the Relevance of Reconnection, Current Disruption and Ballooning Instabilities



Determine the physical processes associated with substorm ignition. Determine relationship between reconnection processes at 25 R_E and instabilities at locations closer to Earth. What determines whether a substorm or a pseudobreakup will occur?

Global Consequences of Magnetic Reconnection:

B. Define the Controlling Magnetosheath Reconnection Processes and Sites and Quantify the Relative Importance for System Dynamics



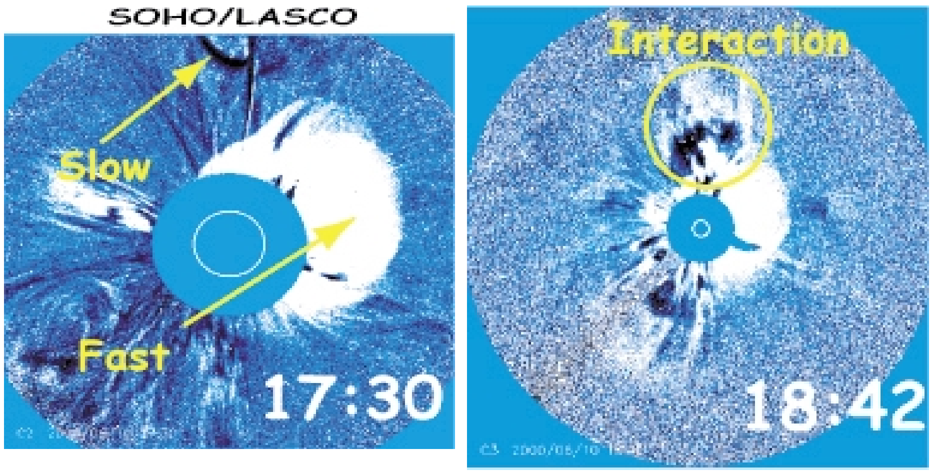
Understand the large number of magnetic irregularities in the structured solar wind and the ability of the Earth's fields to cope and readjust to the frequent rearrangements of the boundary conditions.

ISTP/GGS

Program Element 4a

Quantify the 2-D Structure and Evolution of Large-Scale Interplanetary Configurations and their Interaction with the Magnetosphere:

A. Understand the Evolution and Dynamics of Large-Scale Interplanetary Structures: Implications for CMEs, Shocks, and Solar Energetic Particles



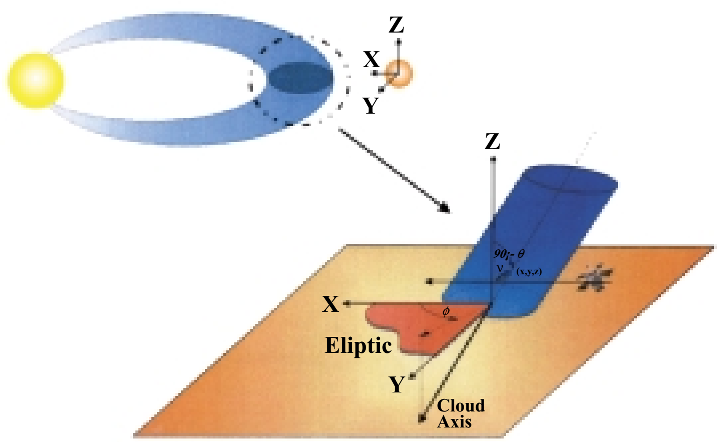
Determine and understand the 3-D configurations and evolution of ejecta and the implications for understanding CMEs, shocks, and solar energetic particles.

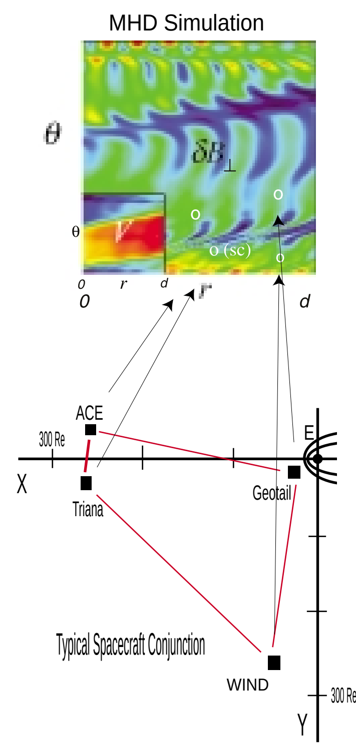
ISTP/GGS

Program Element 4b

Quantify the 3-D Structure and Evolution of Large-Scale Interplanetary Configurations and their Interaction with the Magnetosphere:

B. Extrapolate Upstream Solar Wind Conditions to the Magnetosphere

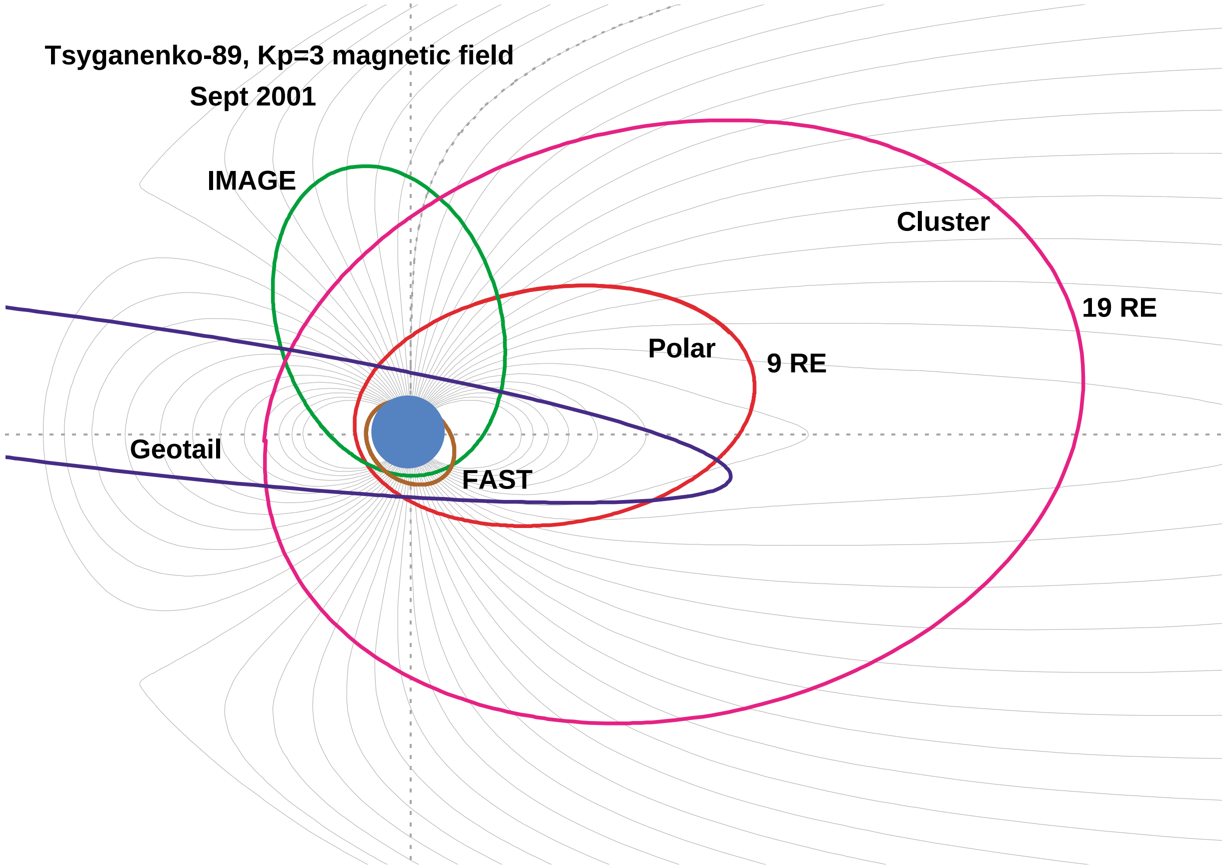




Determine and understand the 3-D structure of meso to large scale (20-200 R_E) interplanetary solar wind structures.

ISTP/GGS

Nightside Equatorial Opportunities

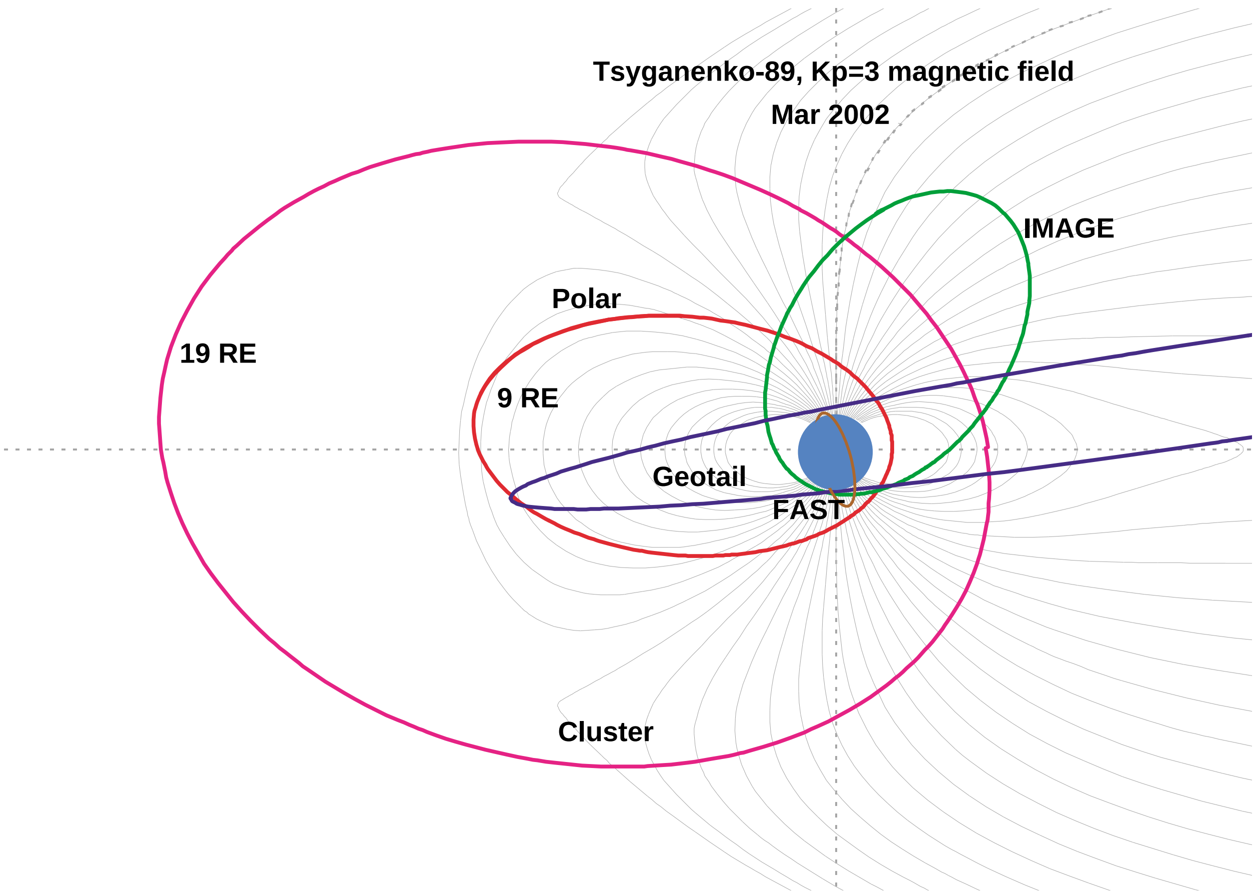


Science Promise

- The long awaited understanding of substorm instability and onset mechanisms
- Ionospheric ion outflow trajectories through the lobes to the plasma sheet
- Equatorial storm plasma injection and loss

ISTP/GGS

Dayside Reconnection Opportunities

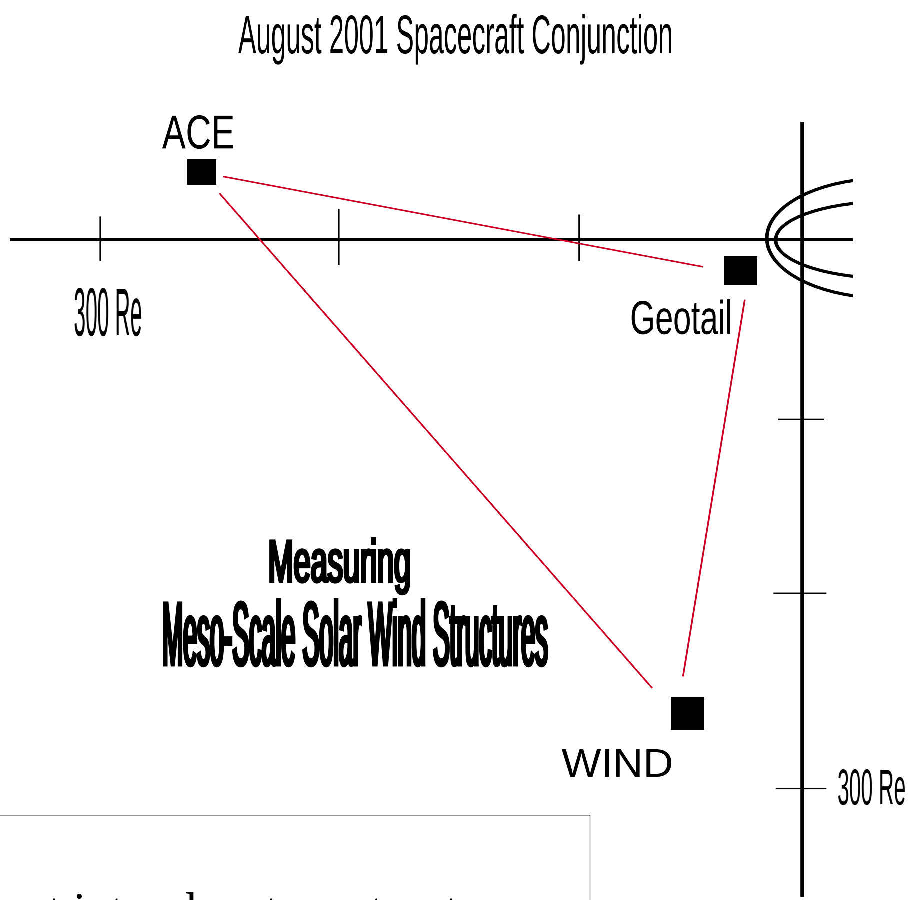


Science Promise

- Simultaneous reconnection measurements from two orthogonally orbiting spacecraft
- Improved plasma transport and magnetic pulsation models

ISTP/GGS

Multipoint Solar Wind Input



Science Promise
- Topologies of important interplanetary structures
- Improved solar wind input functions
- 3-D tracking, with Ulysses, of CME-driven shocks

Summary

ISTP/GGS

ISTP/GGS is the RIGHT THING

WIND
- Radio and plasma waves, 3-D CME tracking
- Complete coverage of the particle phase space of interest
- Solar energetic particle measurements

POLAR
- Fully 3-D magnetic and electric fields
- Complete coverage of particle phase space
- Multispectral auroral imaging

GEOTAIL
- 3-D magnetic and electric fields
- Excellent coverage of the particle phase space of interest
- Electric and magnetic field waves

Integrated Ground-based Investigations and Theory Program
- Canopus, SESAME, Sondrestrom, SuperDARN
- Improved solar wind input functions

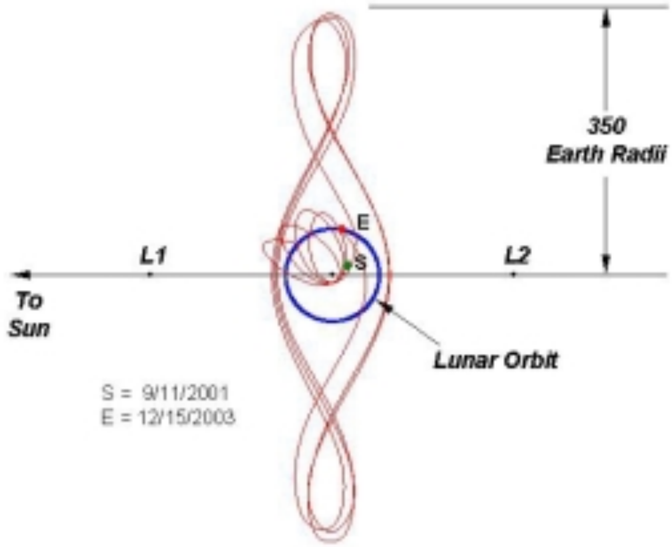
ISTP/GGS in the RIGHT PLACE

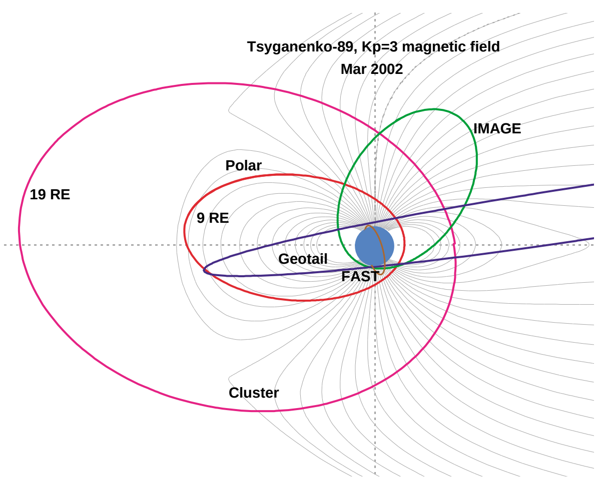
The new ISTP/GGS science goals are possible for three reasons:

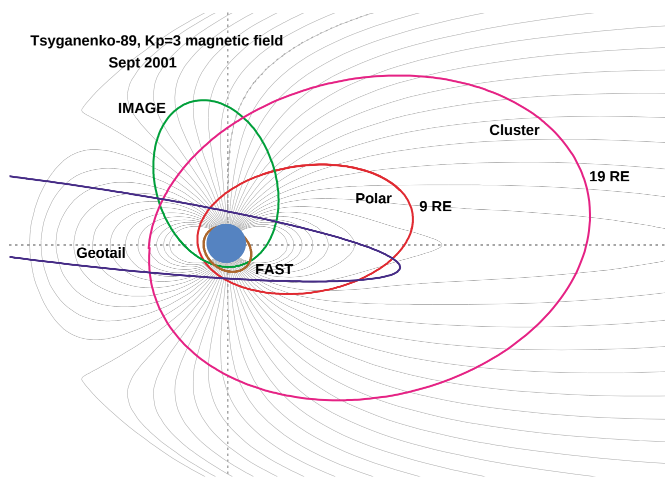
1) the GGS spacecraft are healthy

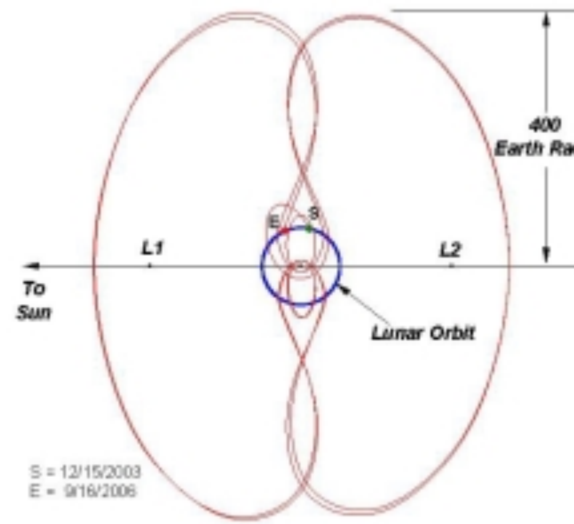
2) The original GGS spacecraft have been joined by the last element of ISTP, Cluster, and other SEC-related missions, including SAMPEX, FAST, ACE, IMAGE

3) The GGS spacecraft orbits have been strategically altered or have precessed into ideal positions from which to study the critical dynamic processes associated with the declining phase of the solar cycle.



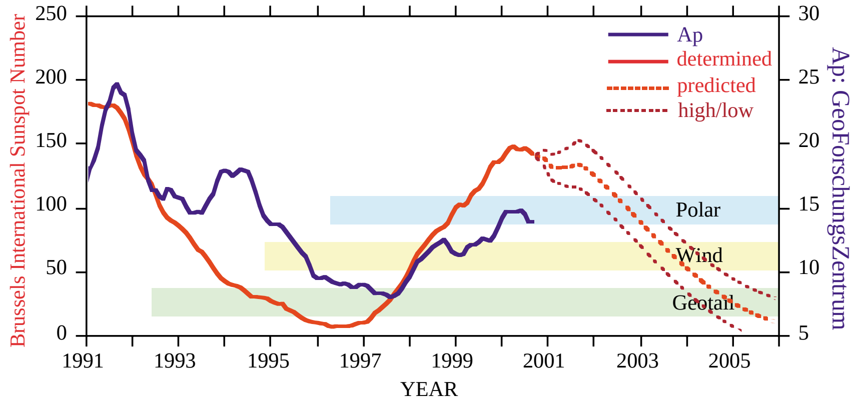






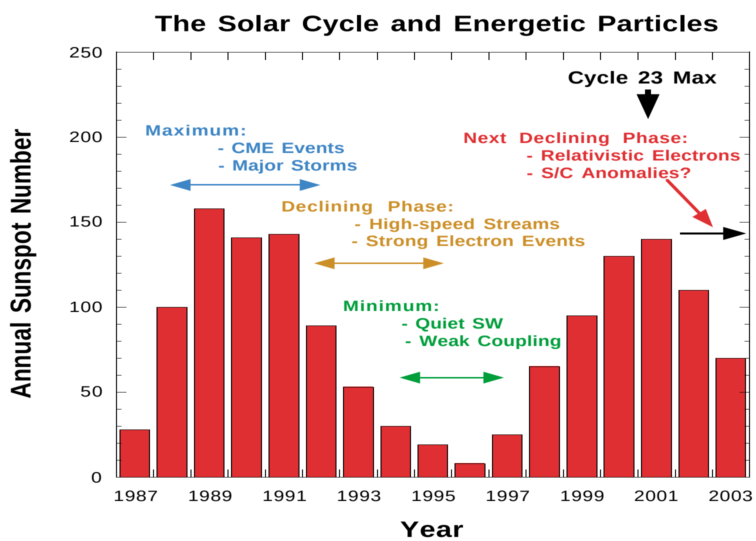
ISTP/GGS

at the RIGHT TIME

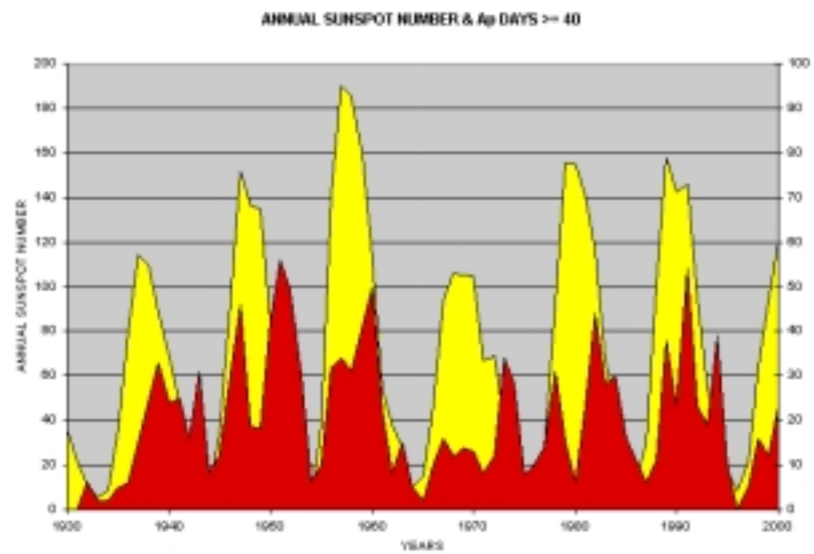


Prediction values are based on ISES cycle 23 forecast

The role of ISTP will be to complete the process of understanding how solar wind-magnetosphere-ionosphere coupling differs during the phases of a solar cycle.



The magnetosphere’s energetic particle spectrum responds differently during the phases of an 11-year solar cycle.

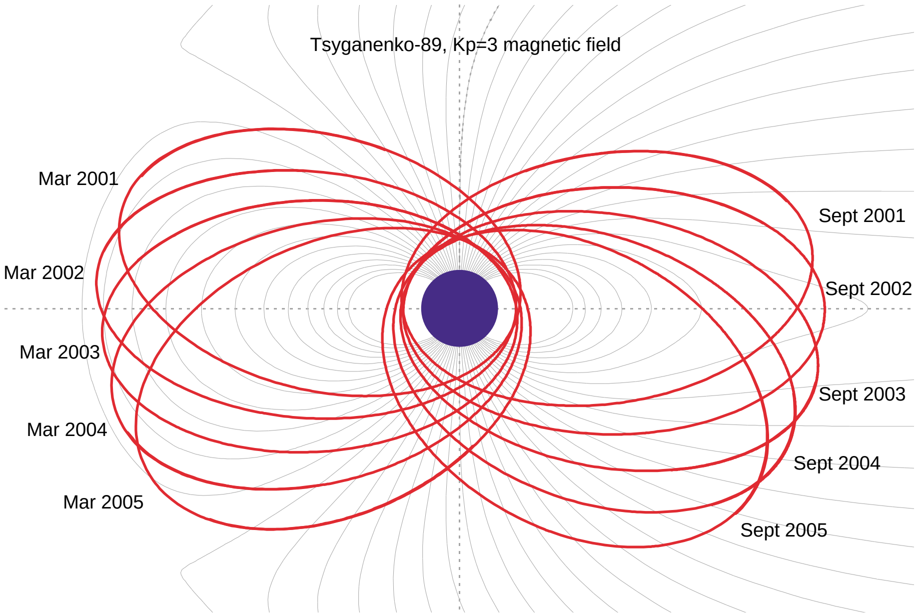


Solar cycle decline is typically associated with a greater number of geomagnetically active days per year

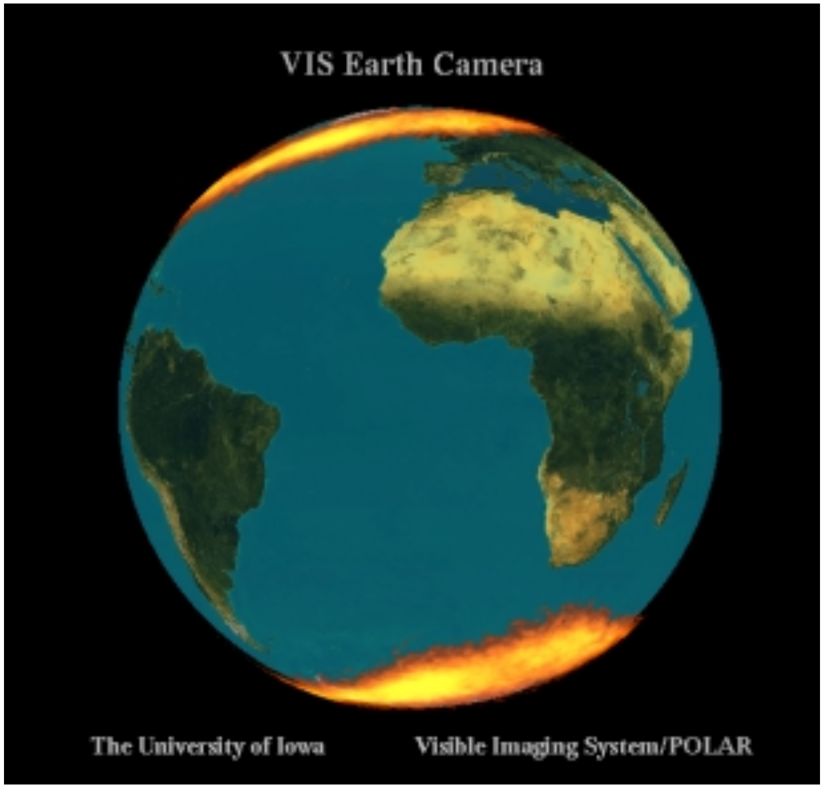
BACKUP

ISTP/GGS

Auroral Viewing

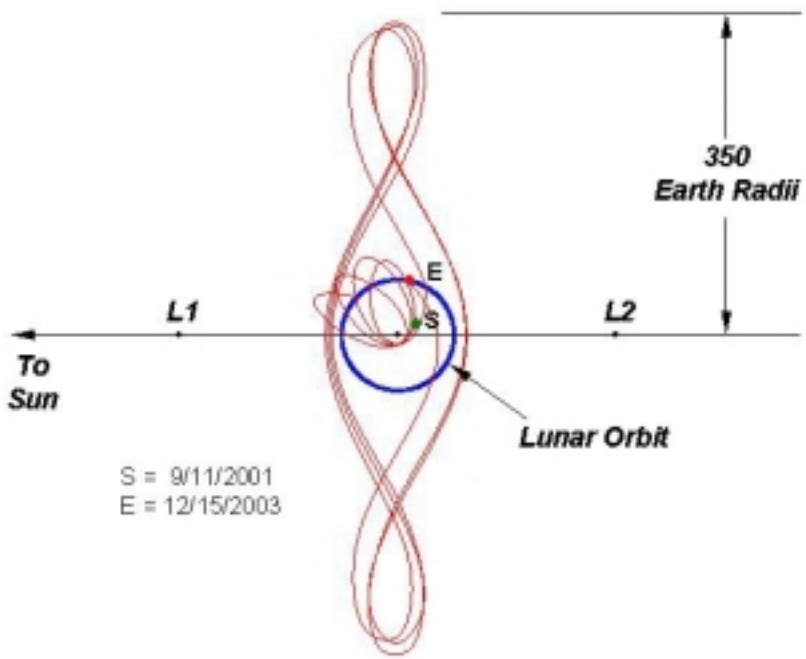


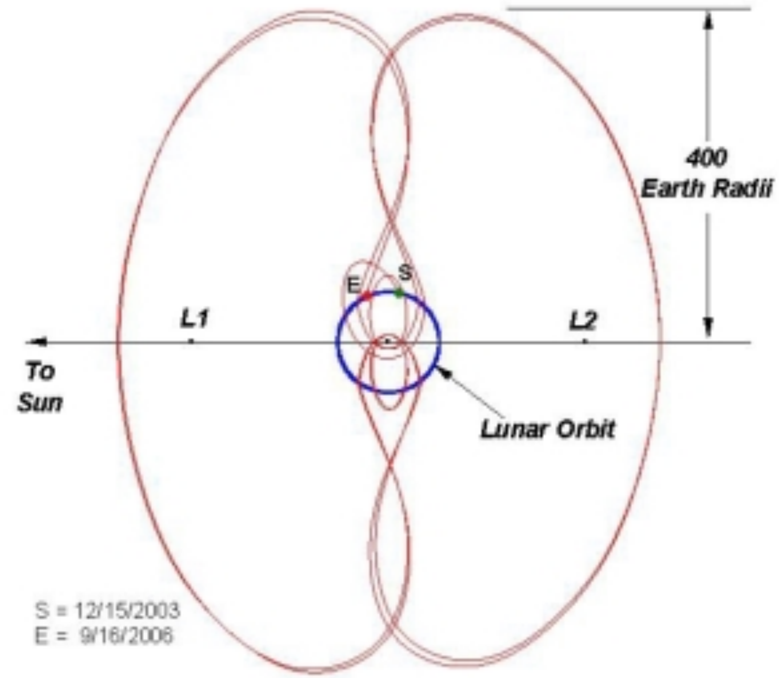
Sample 17-hour orbit trajectories for the Polar spacecraft during the fall and spring seasons.



Simulated auroral imaging capabilities of the VIS Earth Camera with Polar apogee near the equator. The field-of-view is sufficiently large to simultaneously image both Northern and Southern hemispheres.

Wind

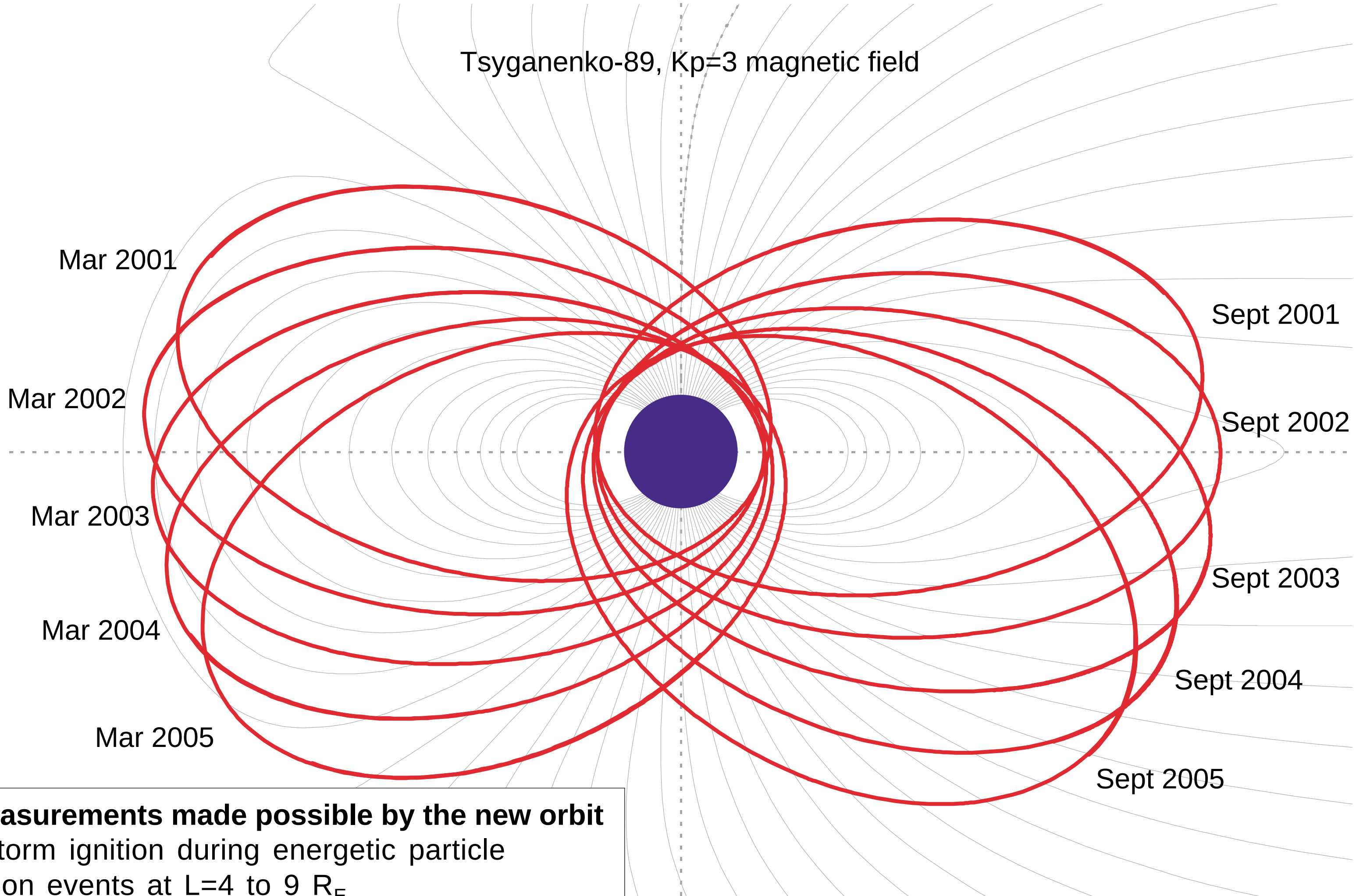




Key Measurements made possible by the new orbits

- Interplanetary structures on meso-scale lengths for the first time
- Full 3-D tracking of CMEs by Wind Waves and Ulysses URAP
- Response of the very deep magnetotail during dynamic conditions

Polar

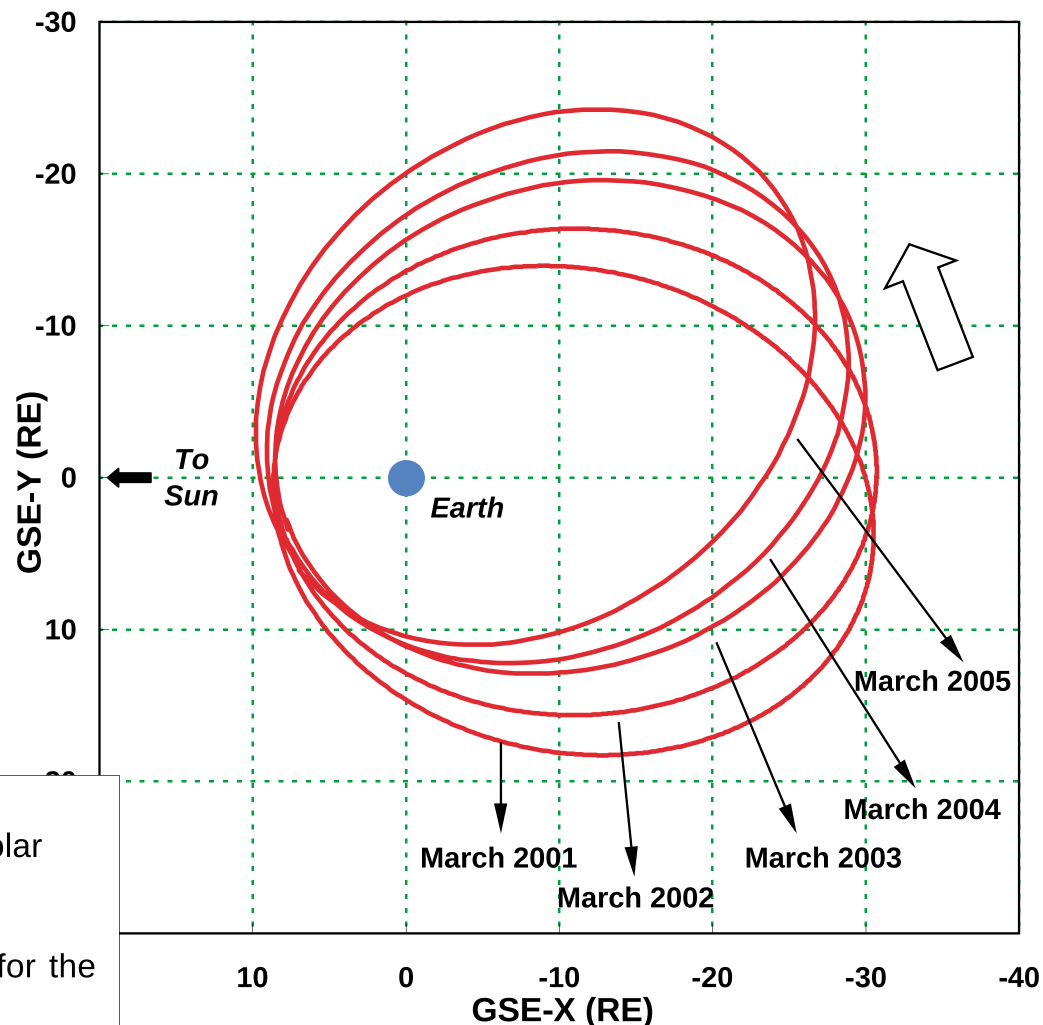


Key Measurements made possible by the new orbit

- Substorm ignition during energetic particle injection events at L=4 to 9 R_E
- Dayside merging
- Radiation belt traversals with full fields and particle measurements
- Dual hemisphere imaging

ISTP/GGS

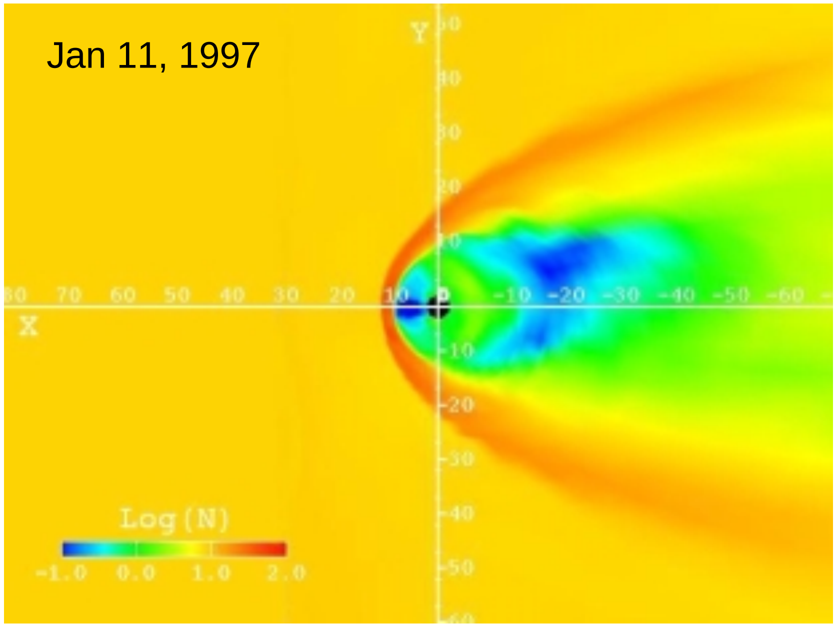
Geotail



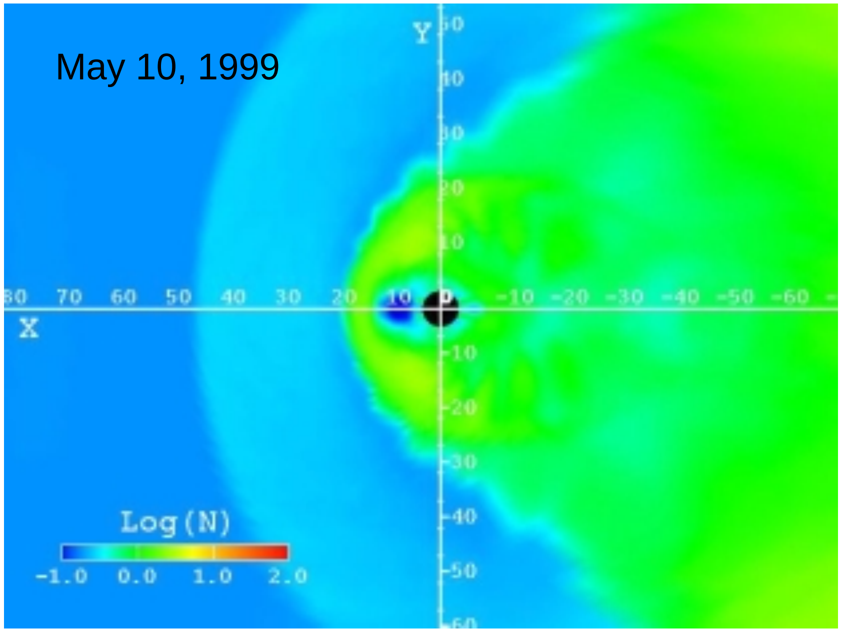
Key Measurements

- Rapid substorm flows tailward of Polar
- Low latitude boundary layer measurements near Polar
- Magnetotail plasma sheet as input for the ring current
- Near-Earth interplanetary particle and field measurements for comparison with Wind and ACE

Theory and Modeling



large impulsive event

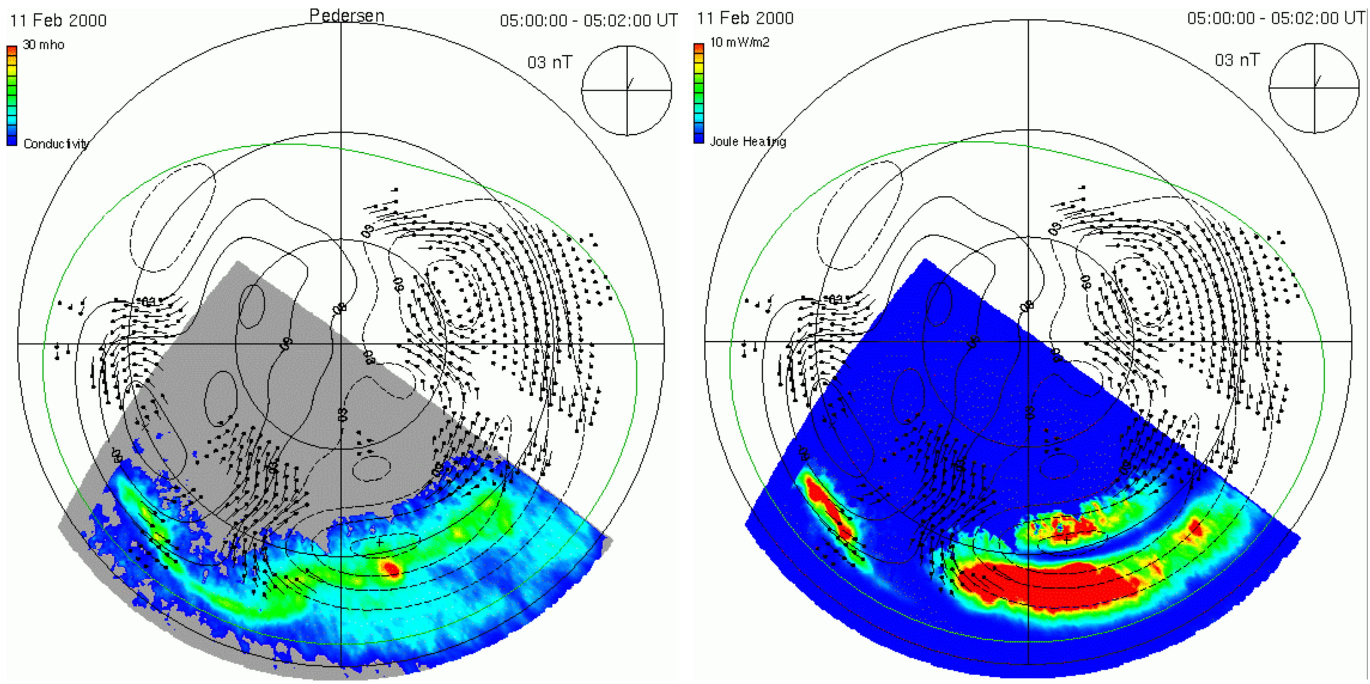


anonymously low flux solar wind

One of the great successes of the ISTP program has been the development and utilization of comprehensive MHD simulations to provide a global context for the widely-spaced ISTP observations.

ISTP/GGS

Ground-based Investigations



SuperDARN convection pattern with superposed ionospheric Pederson conductance (left) derived from VIS and superposed estimate of Joule heating (right).

The extensive network of magnetometers, radar, and optical cameras remotely sense the ionospheric base of the magnetosphere and, along with FAST, provide the final link in the Sun-Earth connection chain, the flow of mass and momentum and energy dissipation into the Earth's atmosphere.

Wind: Instrument Status

Instrument	Capability
MFI	DC — 10Hz vector magnetic field
SWE	3D electron velocity distributions: 7 eV — 22 keV 3D ion velocity distributions: 200 eV — 8 keV
3DP	3D electron and ion distributions: eV — MeV
SMS	Energy, mass, charge composition solar wind ions: 0.5-230 keV/e
EPACT	Energy spectra electrons and ions: 0.1 — 500 MeV/nucleon Isotopic composition, Angular distributions
WAVES	Radio and plasma waves: DC — 14 MHz
TGRS	Gamma ray spectroscopy: 15 keV — 10 MeV
KONUS	Gamma Ray spectroscopy: 10 — 770 keV, high time resolution

Fully Operational

Non-impacting fault

Operates under special circumstances

Non-operational

Polar: Instrument Status

Instrument	Capability
MFE	DC — 10Hz vector magnetic field
EFI	3D electric field Thermal electron density
PWI	Spectral and wave vector characteristics: 0.1 Hz to 800 kHz
CAMMICE	Energetic particle composition: 6 keV/Q to 60 MeV per ion
CEPPAD	Protons: 10 keV to 1 MeV; electrons: 25 to 400 keV
HYDRA	3D electron distributions 3D ion distributions: 2 — 35 keV/e
TIMAS	3D mass separated ions: l5 eV/e to 32 keV/e
TIDE	2D ions: 0 to 500 eV/e
UVI	Far ultraviolet auoral imager: 130.4, 135.6, 140-160,160-175, 175-190 nm
PIXIE	X-ray auroral imager: 3 to 60 keV
VIS	3 low-light level auroral cameras: 130.4, 391.4, 557.7, 630.0, 656.3, 732.0 nm

Fully Operational

Operates under special circumstances

Non-impacting fault

Non-operational

Geotail: Instrument Status

Instrument	Capability
MGF	**DC — 8 Hz vector magnetic field**
EFD	**Double Probe Electric Field**
PWI	**Electric (0.5 Hz —400 kHz) and Magnetic (1 Hz —10 kHz field waves)**
HEP	**Energetic and High Energy Cosmic Ray particles**
EPIC	**Energetic Particles and Composition 10 -230 keV**
LEP	**3D velocity distributions: 7eV-42 keV ions, 6 eV-36 keV electrons**
CPI	**3D velocity distributions: 1eV-50 keV ions and electrons**

Fully Operational

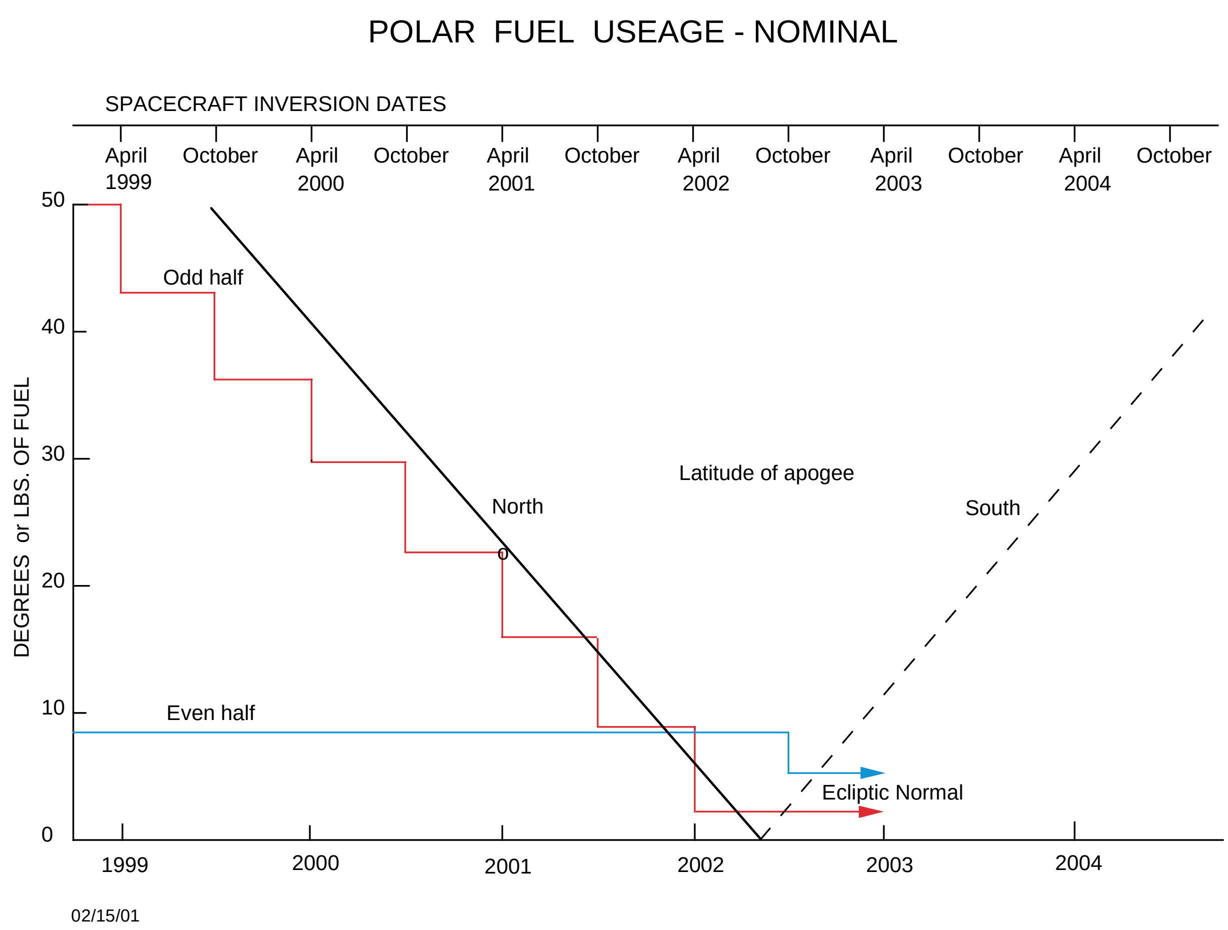
Operates under special circumstances

Non-impacting fault

Non-operational

ISTP/GGS

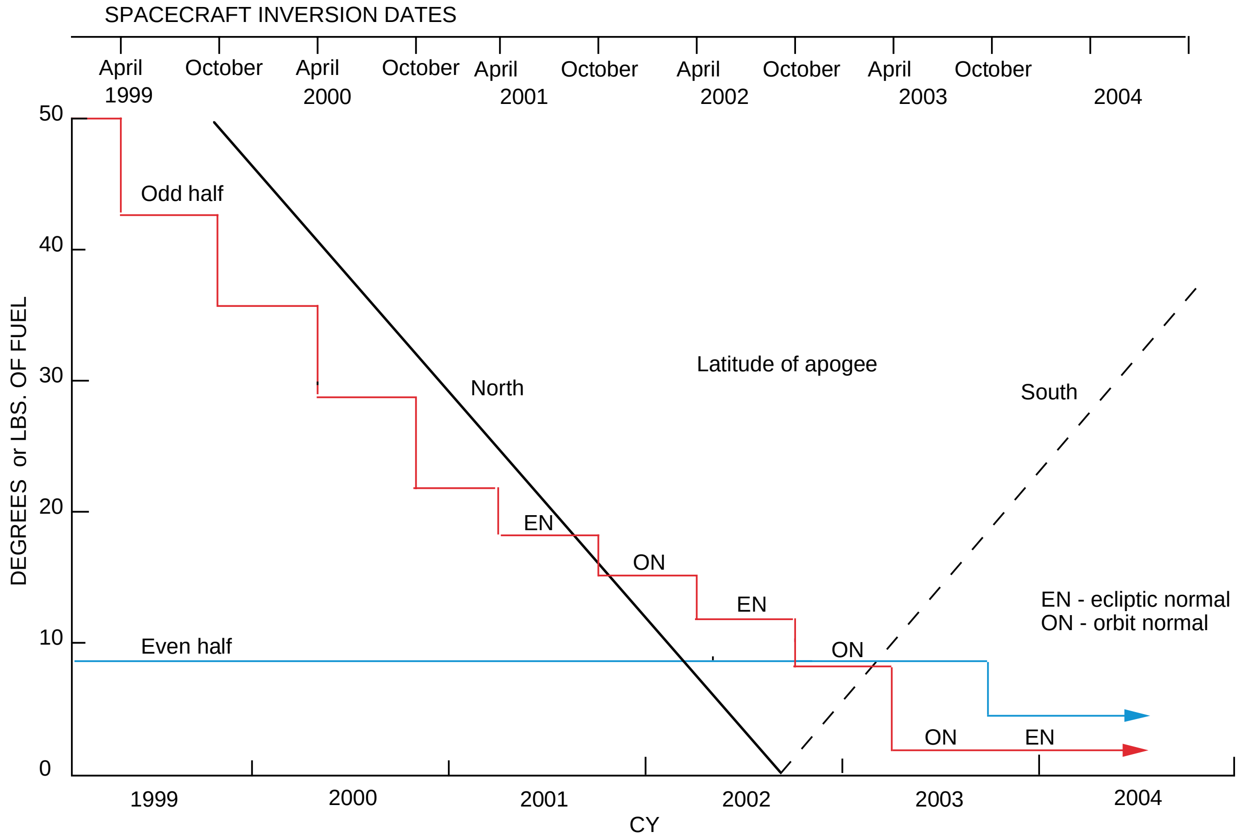
Polar Fuel Reserves: nominal



ISTP/GGS

Polar Fuel Reserves: option

POLAR FUEL USEAGE - OPTION 2



10/20/00

Polar Fuel Reserves: option